Serpentine Prairie Restoration Project Redwood Regional Park

2010 Annual Report: Year 2

A Creekside Center for Earth Observation Project
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Executive Summary

The Serpentine Prairie Restoration Project was initiated in 2008 to restore native serpentine flora and monitor the population of Presidio clarkia (*Clarkia franciscana*), a federal- and state- endangered annual forb. The Redwood Regional Park – Serpentine Prairie study area is a located on land owned and managed by the East Bay Regional Park District (EBRPD). This report fulfills the requirement to produce an annual report for this project.

Presidio clarkia numbers have increased from 2008 to 2010. With 80% confidence, the number of clarkia individuals in the macroplot in 2010 is estimated to be 85,830 ± 17,607. This number has climbed from 15,569 ± 1888 individuals reported in 2008 and 63,210 ± 8627 individuals in 2009. Based on these results, climate seems to critically influence the annual population of clarkia. The longer growing seasons with late rain in 2009 and 2010 likely provided conditions that favored clarkia.

Spring mowing stands out as an effective treatment for 1) reducing non-native annual grass cover, 2) increasing annual forb cover, and 3) decreasing thatch cover. The results from 2010 indicate that the effect of spring mowing was even more pronounced after two successive years of treatment. Total annual grass cover was reduced by 50% in the spring mow treatment plots.

After the first phase of tree removal occurred in December 2009, spring 2010 clarkia counts in the tree removal plots increased 8-fold. Additionally, clarkia individuals were discovered in an area where mature pines were removed (near plots F5 and C5) in 2009, where the canopy of the trees and the pine litter would have likely otherwise suppressed these individuals from germinating. This passive recruitment response may be due to stimulation of a decades-old seedbank, or to more recent dispersal.

Introduction

The Redwood Park Serpentine Prairie is the largest undeveloped outcrop of a much larger expanse of exposed serpentine soils that once existed in the Oakland Hills, between Skyline Boulevard and the Warren Freeway and north east to Joaquin Miller Park. In the 1960s, hundreds of pines and acacias were planted. More recently, shrub-dominated vegetation has expanded around the margins of the prairie, and an increasing number of park users have also added to the impacts on the landscape. The purpose of this restoration plan is to restore the vitality and botanical diversity of the Serpentine Prairie, manage the site to ensure survival of special status species associated with the prairie, and provide for the enjoyment and appreciation of the park users [excerpted from EBRPD, 2008]. Particular emphasis is placed on managing the federal- and state-listed endangered Presidio clarkia (*Clarkia franciscana*)[1].

Methods

The experimental design requires a total of 32 permanent plots measuring four treatments: fall rake, spring mow, tree removal, and control (Maps 1-3). Eight 10x10 meter plots were established for each treatment. Four plots from each treatment were located inside of the fencing enclosure, and four outside the enclosure.

Permanent plot locations were rejected if they were within two meters or overlapping with another plot or the proposed fence enclosure. Plots were randomly selected within appropriate habitat, which was defined by the following criteria:

Fall Rake

Eight fall rake plots were located in areas where clarkia and thatch were present, with raking occurring only after clarkia seed set. We did not anticipate the population to be negatively impacted by raking the thatch from these plots. Raking was expected to reduce thatch, which has been shown to inhibit germination of forbs such as clarkia.

The fall rake treatment occurred in September for both years, before the first rains but after the majority of the clarkia capsules had opened, allowing seeds to

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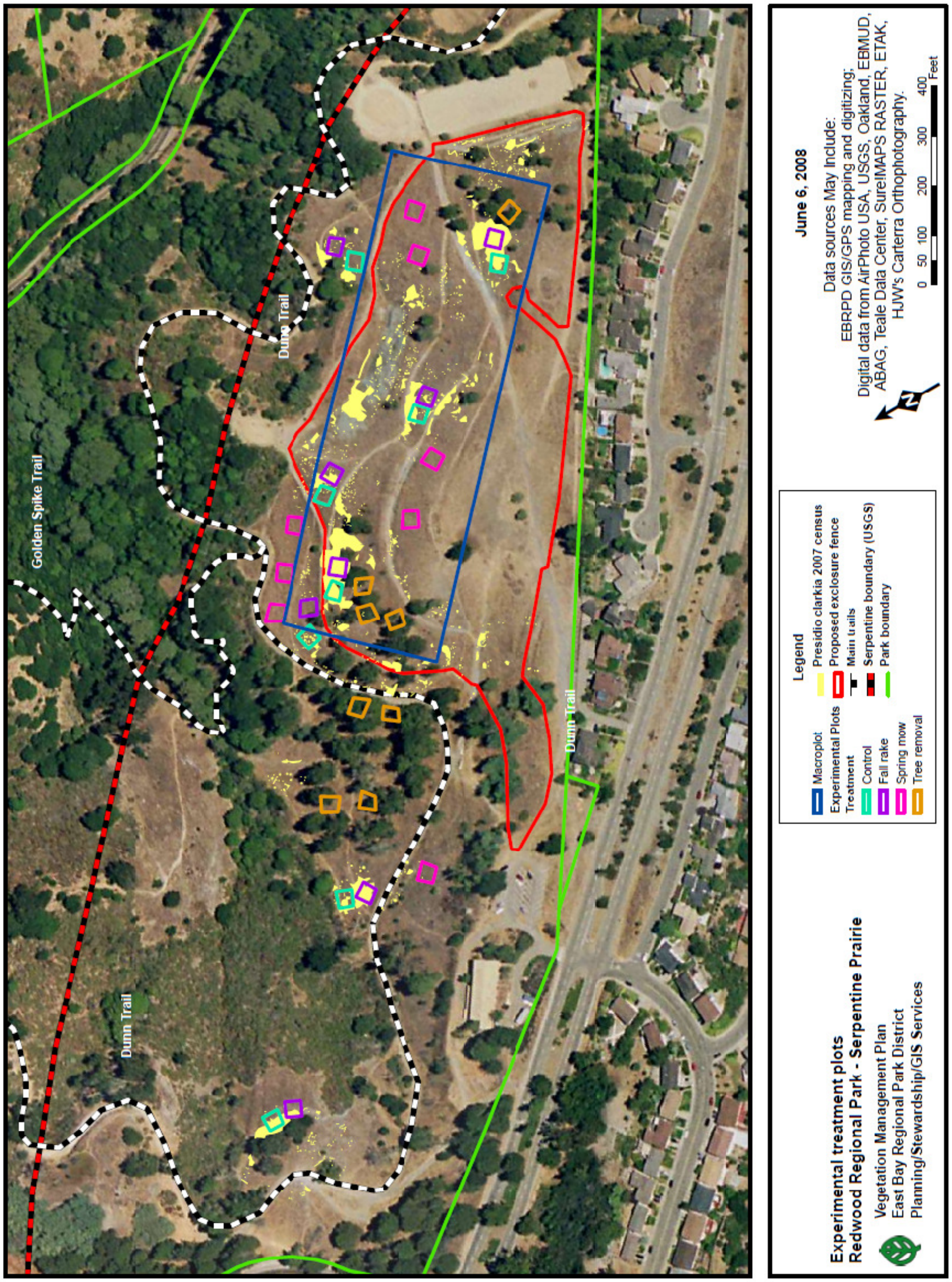
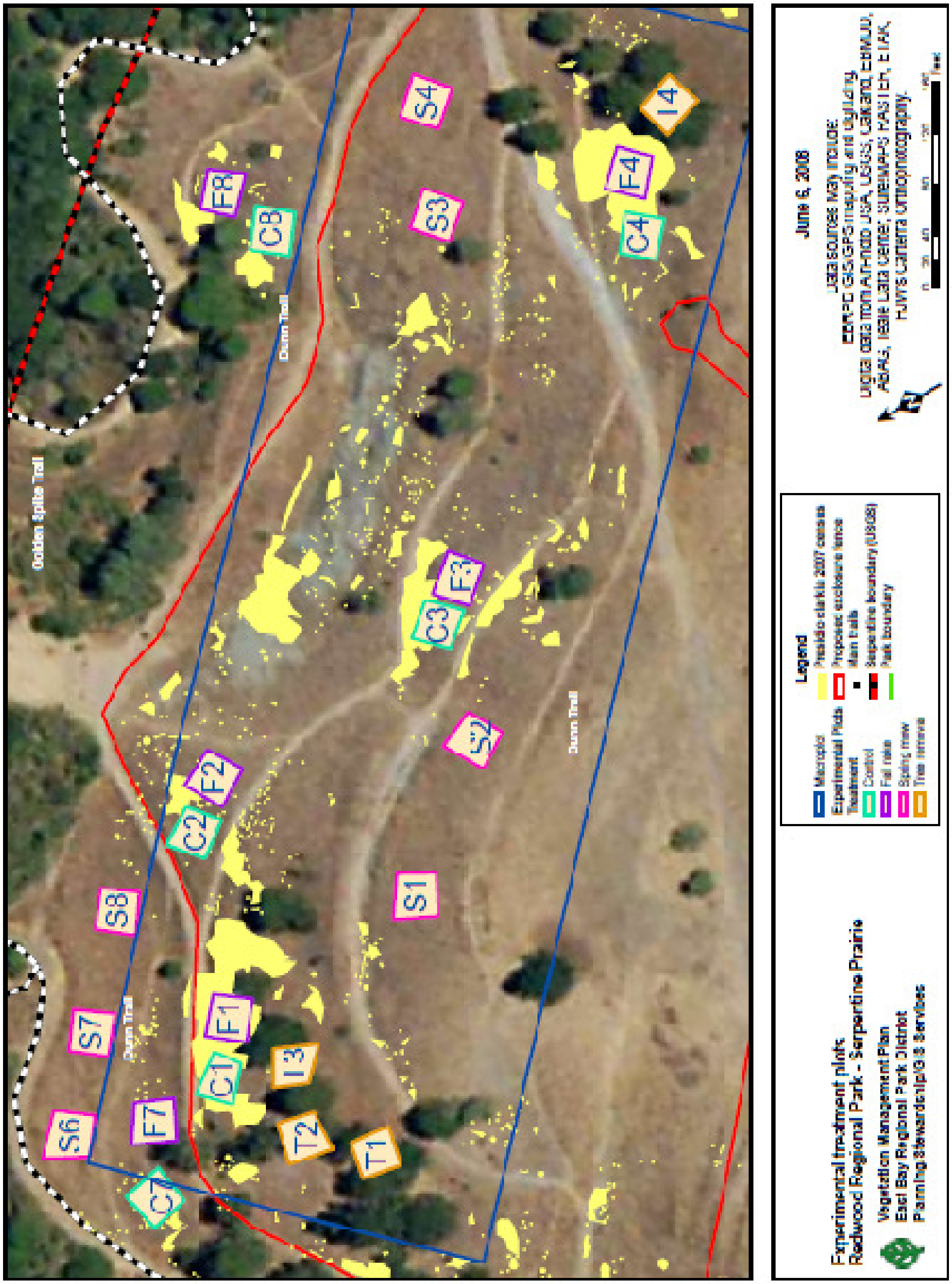
1 Presidio clarkia will hereby be referred to as "clarkia" since no other clarkia taxa are found in the study area.

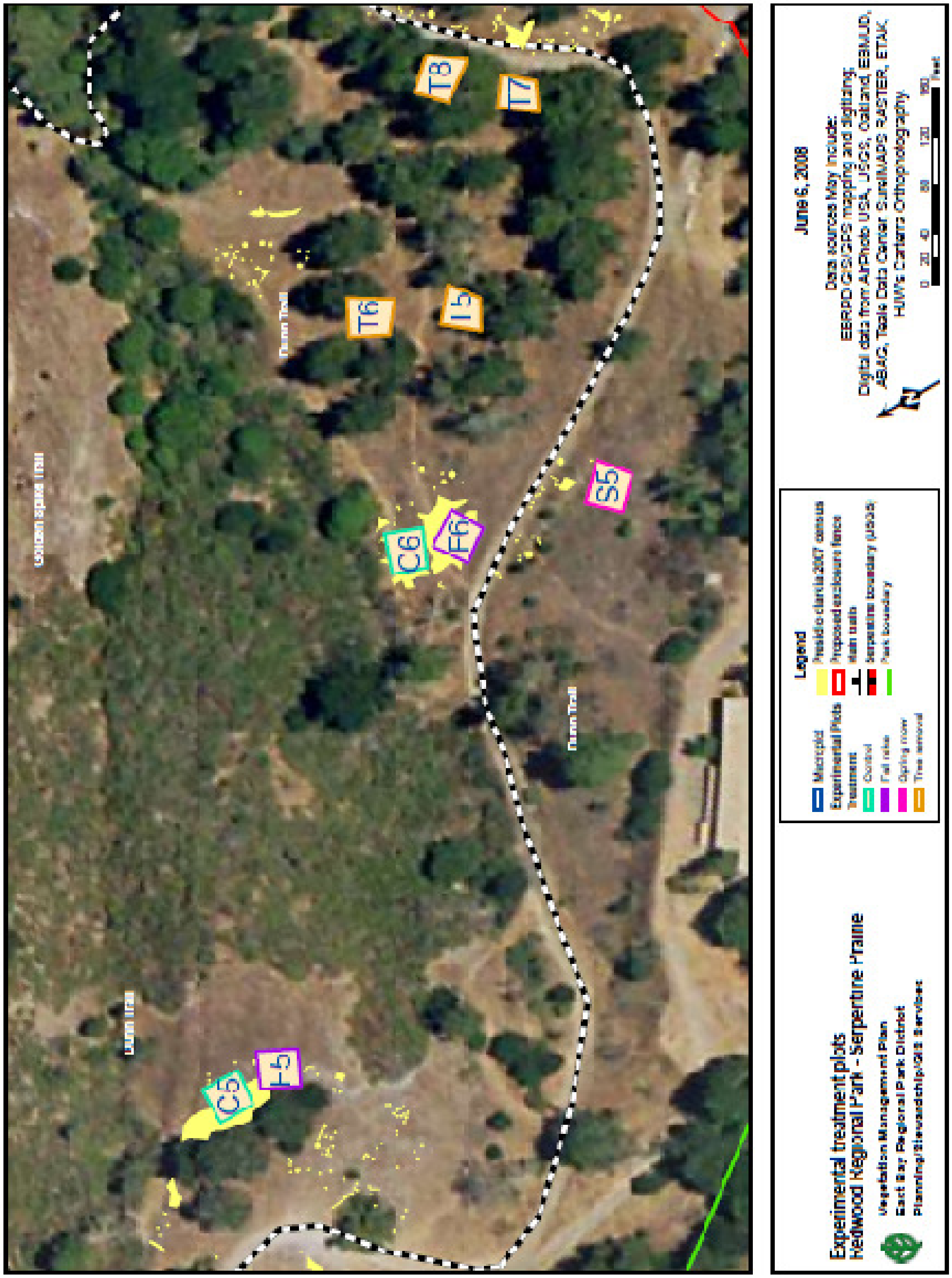
Map 1: Plot locations



Map 2: Eastern plot locations



Map 3: Western plot locations



naturally fall to the ground. Raking was completed with a metal rake until bare ground was visible (Plate 1).

Plate 1: Fall rake treatment, plot F8

Spring Mow

To avoid take, the eight spring mow plots were located in areas where clarkia had not been observed in previous years. Spring mowing was anticipated to reduce cover of annual grass, which has been shown to outcompete annual forbs such as clarkia.

The spring mow treatment was carried out in April (2010) and May (2009) prior to peak phenology for non-native annual grasses (Plate 2). The precise date of this treatment will vary from year to year. Italian ryegrass (*Lolium multiflorum*) and foxtail barley (*Hordeum murinum* ssp. *leporinum*) are the two non-native annual grasses that have the highest cover throughout the Serpentine Prairie. The mowing is timed to occur after the bulk of these grasses are flowering, but before seed maturation. Mowed material was left in the plot to decompose.

Tree Removal

The eight tree removal plots were located in areas of dense pine (*Pinus* spp.) stands where shade from the trees and leaf litter affected the understory. These areas were not expected to have clarkia, or very low cover of clarkia, due to shading and a thick duff layer of needles.

Plate 2: Post-treatment of spring mow plots S7 and S8

Phase one of tree removal occurred in August/September of 2009. This phase removed trees that were formerly impacting plots T1, T2, and T3. 2010 represents the first year the vegetation data collected in T1 – T3 reflect tree removal.

In 2010, trees located in and near plots T4, T7, and T8 were also removed. This removal occurred **after** the vegetative season, so the effects of additional tree removal won't be seen until next year's report.

Control

The eight control plots were placed in areas occupied by clarkia, to monitor the natural variation in the clarkia population. Controls help determine whether changes in experimentally treated plots are actually due to the treatment, or to weather or other variables.

Clarkia counts took place in the entire 10x10 meter experimental plot. Vegetation composition data were collected at peak phenology in five 0.5x0.5 meter quadrats located systematically in the 10x10 meter plots (Figure 1, Plate 3).

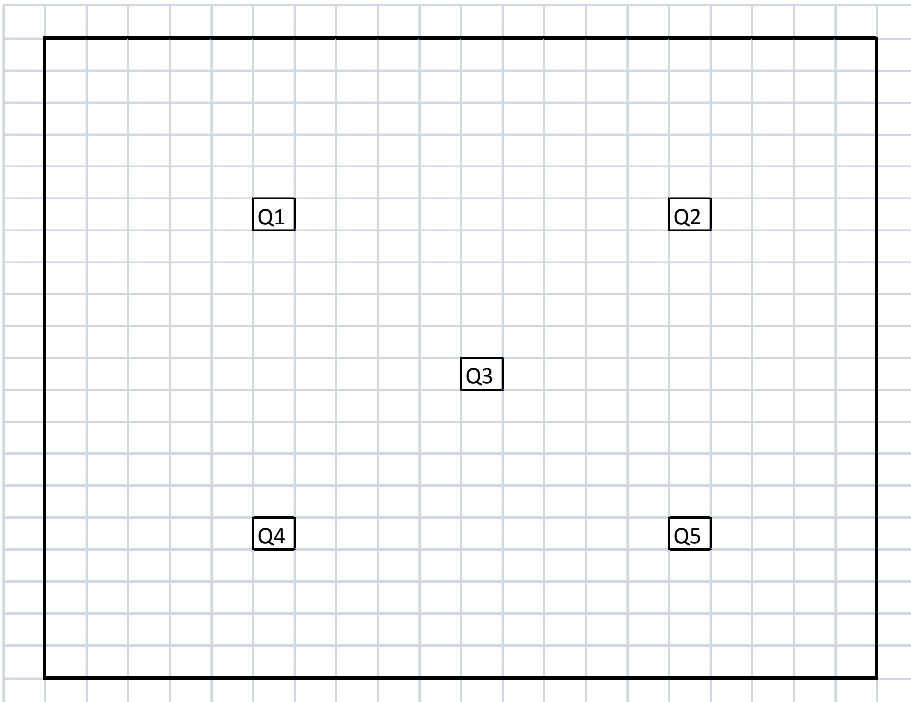


Figure 1: Location of 0.5x0.5m quadrats in each treatment plot, facing uphill.


Plate 3: Data collection at one of the 32 permanent plots

Fenced Enclosure

A fence circumscribing a significant portion of the serpentine prairie was planned for completion in 2008, but was completed in December 2009. Starting with this report (year 2), plots numbered 1, 2, 3 and 4 are located inside of the fence enclosure, while plots 5, 6, 7, and 8 are outside of the enclosure, where dog and pedestrian traffic still regularly occurs.

Completed Tasks

Tasks completed by Creekside Center for Earth Observation from 2008 to 2010 include:

- Establishing a 100 x 300 meter permanent macroplot inside the core Presidio clarkia population. Macroplot corners were established with 6 foot T-bar posts hammered approximately 24 inches deep.

- Establishing 32 permanent plots (Maps 1-3) with wooden stakes. All locations were mapped with a sub-meter accurate Garmin GPS.

- Collecting vegetation composition data and clarkia censuses for 32 permanent plots.

- Spring mowing eight treatment plots in April or May with handheld string cutter.

- Fall raking and removing thatch in eight treatment plots in September or October, with metal rake.

- Providing meter-by-meter distribution and density data for clarkia located within the macroplot. This data was used by EBRPD staff to create a density grid within the surveyed area.

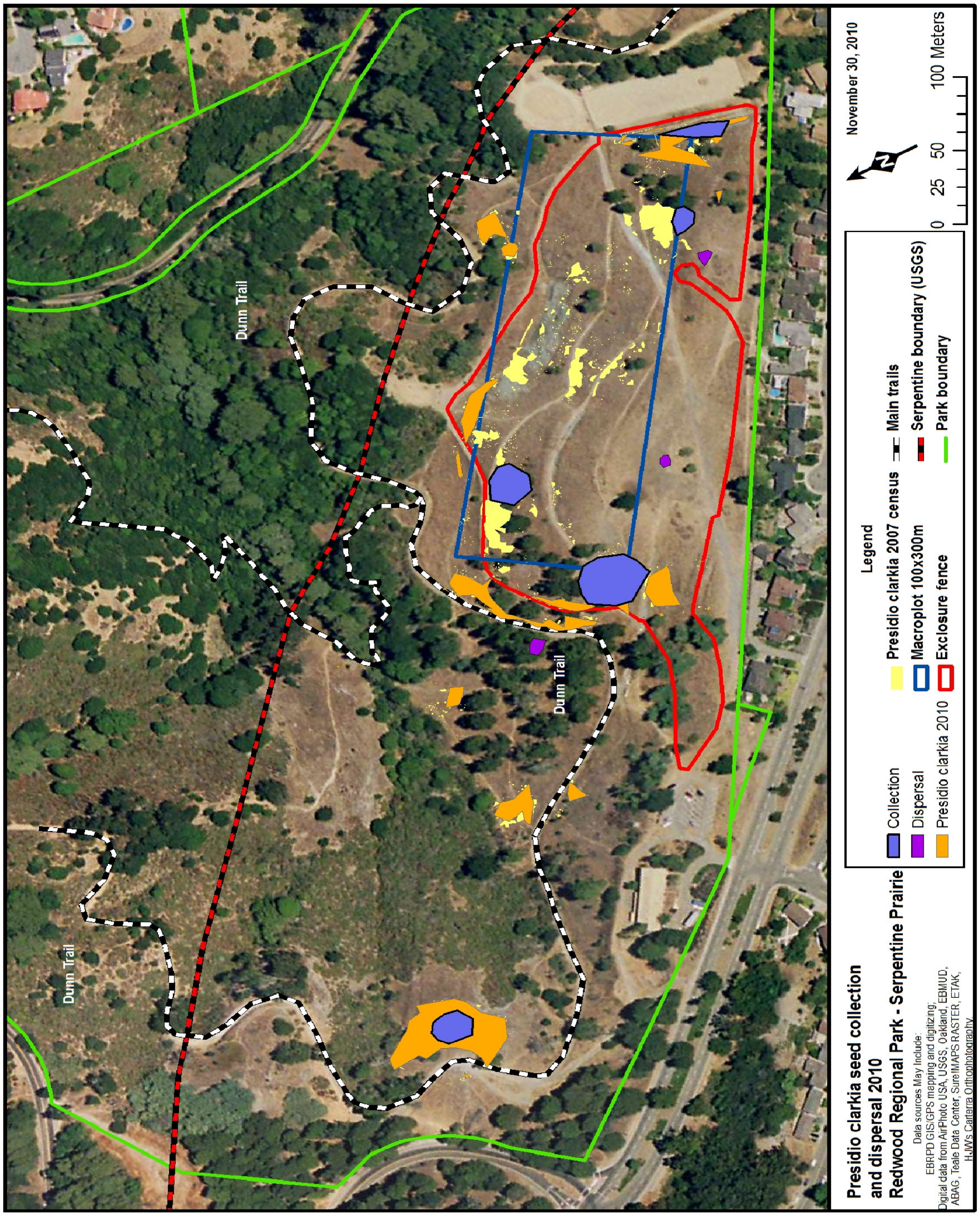
Data Analysis

Data were entered into a Microsoft Access database for analysis. All data were checked for quality control by revisiting all the entered numbers. All data in figures are displayed as the mean with error bars representing the 90% confidence interval. Entries with error bars that overlap the mean of other entries are considered similar.

Seed Collection and Dispersal

In September 2010, seeds from mature Presidio clarkia plants were collected in paper envelopes. No more than 5% of seeds from any given plant were collected to ensure that the existing seed bank was not impacted. Seeds were collected from five different sites: 1) south facing slope near corral, 2) east facing slope near/in plots C4 and F4, 3) west facing slope near plot T1, 4) northeast facing slope near plots C1 and F1, and south facing slope near plots C5 and F5 (Map 4). Seeds were stored in a cool dry place until late October, when they were seeded into three areas where clarkia was not previously surveyed: two areas in the former Hunt field, where the slope was nearly 0 and bedrock was visible, and near the T7 and T8 plots where a portion of the existing dense pine stand was removed in 2010. All areas where seeds were introduced are free of overstory trees. Collected seeds were evenly divided between the three relocation sites (about 200 seeds per site), ensuring that seeds from each of the five collection areas were disseminated in each relocation area. Relocation areas where seeds were spread were limited to 4 meter diameter circles so that any new germinating plants could be easily found the following year. Year 3 will report if seed relocation efforts produced seedlings and mature clarkia plants.

Map 4: Location of clarkia seed collection and dispersal



Results

Macroplot

With 80% confidence, the population of clarkia in the macroplot for 2010 is 85,830 ± 17,607 individuals. The population of the macroplot in 2009 was 63,210 ± 8627 individuals and 13,845 ± 1888 in 2008. A total of 10% of the macroplot was sampled to achieve this estimate.

Annual climatic variation affects the distribution and frequency of annual plants. Clarkia flowers late in the spring (May-June) and probably benefits from late season rains. The total precipitation in 2010 was 28.3 inches, well above the previous years of 2008 and 2009, when total precipitation was 21.1 and 21.9, respectively (Westmap, 2010). The spring precipitation (March-June) for 2008 was 0.81 inches (the lowest in 10 years) versus a 2009 precipitation of 4.95 inches. Spring 2010 precipitation was even higher at 8.94 inches (Figure 2).

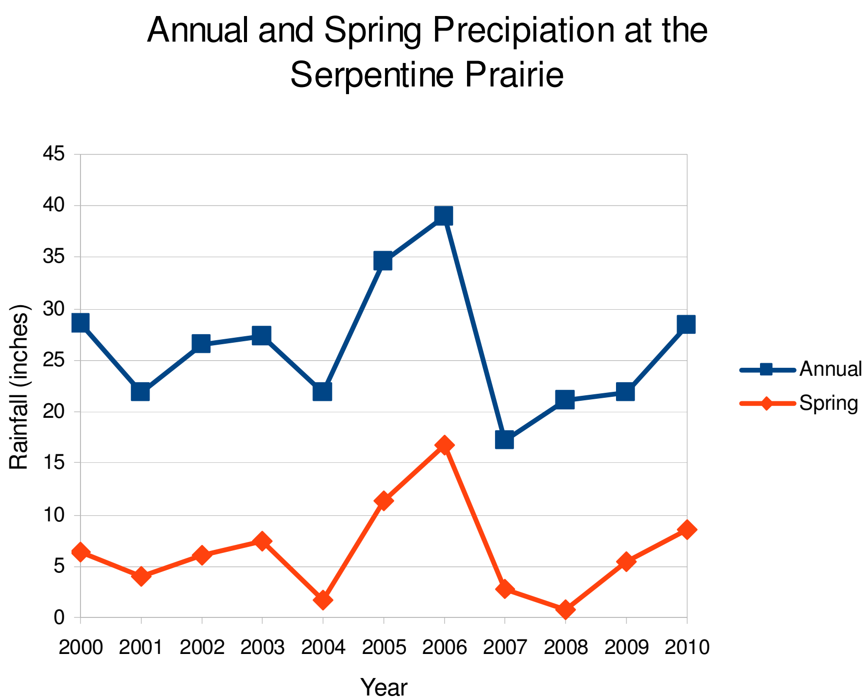


Figure 2: Precipitation at the Serpentine Prairie (37.8129, -122.187675): annual data (Oct-Sept) and spring (Mar-June).

Increased clarkia census numbers correspond with increases in spring precipitation. Similar inter-annual variability in clarkia is seen in populations at the

Presidio, San Francisco, where large swings in population size can occur from year to year (Figure 3).

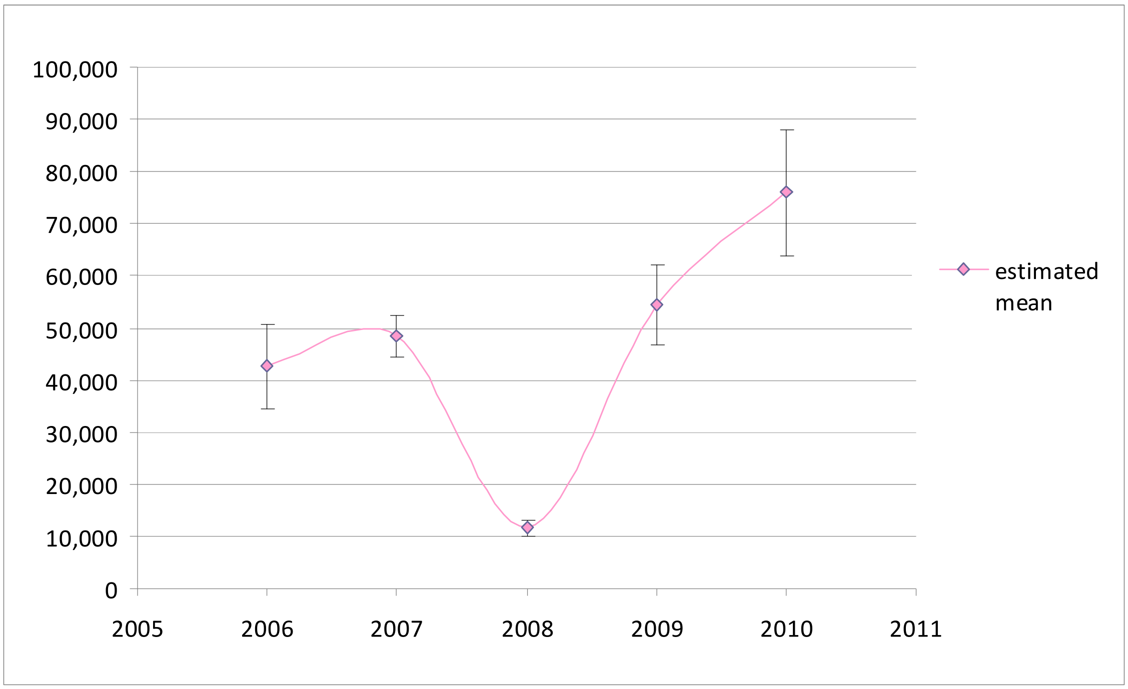


Figure 3: Total count of individuals of clarkia at Inspiration Point, San Francisco. Data from L. Stringer, The Presidio Trust.

Clarkia Cover

No notable change in clarkia cover was observed in any of the treatments during the first two years of data collection (Figure 4).[2] Since clarkia is a diminutive annual forb, a one percent increase in cover would indicate a logarithmic increase in plants at the survey site. Cover is not the best tool for recording changes in the population of clarkia. Instead, census data and population estimates provide better information on the extent of the population. Results from both of those methods are presented in this report.

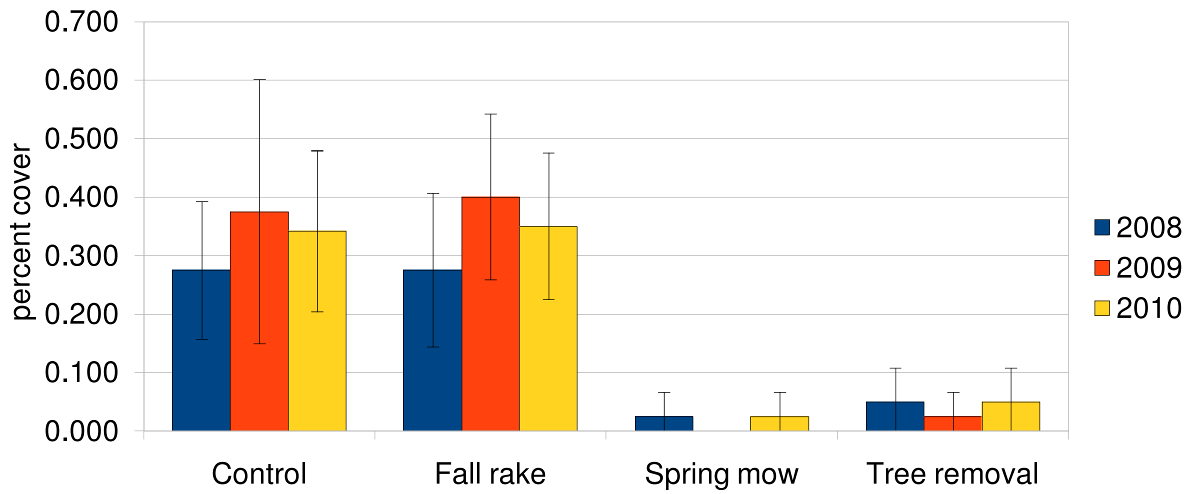


Figure 4: Percent Cover of Clarkia

[2] All data in figures are displayed as the mean with error bars representing the 90% confidence interval.

Clarkia Census

Each experimental treatment plot is 10X10 meters, small enough to allow an accurate clarkia census. Total clarkia per treatment is reported in Table 1.

Table 1: Total clarkia individuals per treatment

	2008	2009	2010
Control	1229	3030	5728
Fall rake	1238	3254	935
Spring mow	0	24	2
Tree removal	15	184	810

Data in 2010 indicate an increase in clarkia in the control plots similar to what was observed in the macroplot estimate. Meanwhile, the fall rake plots show a threefold decrease in population numbers from 2009, similar to the 2008 baseline. Clarkia appeared unexpectedly in spring mow plots in 2009, and decreased in 2010. Clarkia in tree removal plots increased by an order of magnitude in 2009, and nearly as much again in 2010.

Bare Ground and Thatch

The percent of bare ground increased after one year of treatment for both the spring mow and fall rake plots. Notably, the amount of bare ground in the spring mow plots increased stepwise after the second consecutive year of mowing. Neither control nor tree removal plots have shown appreciable changes in bare ground (Figure 5).

Thatch declined in the fall rake and spring mow treatments after one year of treatment, and remained lower than background conditions in the second year (Figure 6). Thatch reduction occurred in the 2010 tree removal plots, even though only three of eight plots had trees and duff removed. Control plots did not show observable changes.

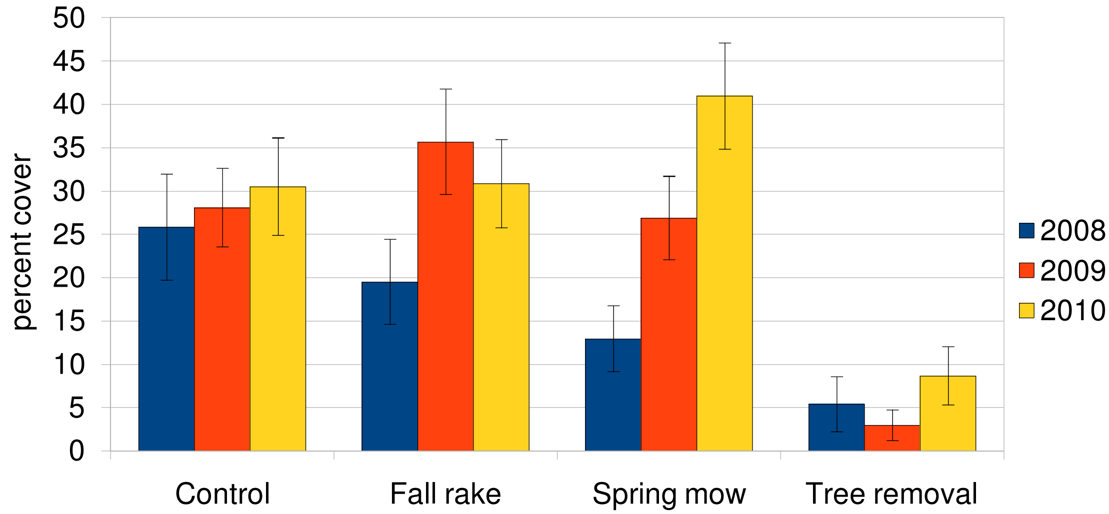


Figure 5: Percent Cover of Bare Ground

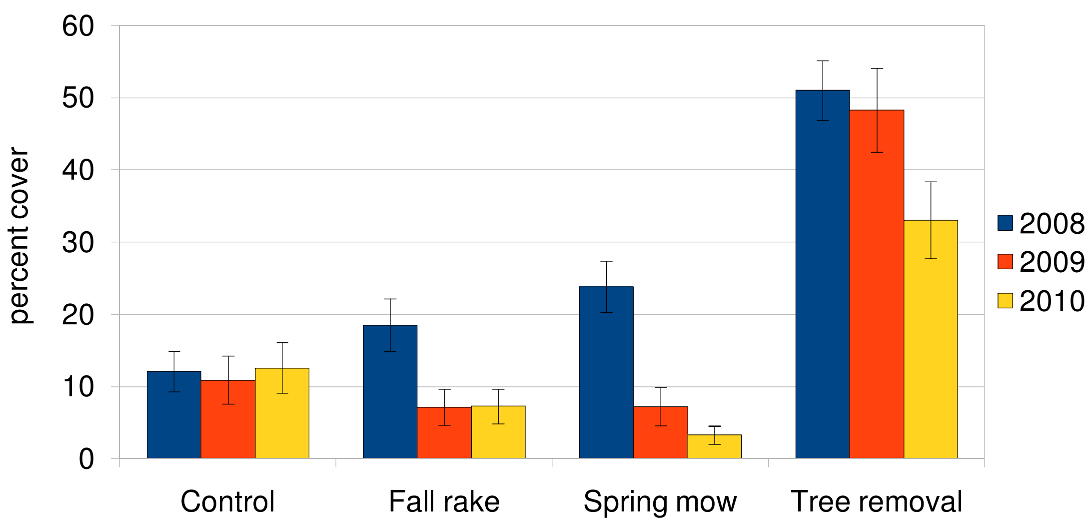


Figure 6: Percent Cover of Thatch

Treatment by Guilds

Grassland flora is categorized into annual grasses, perennial grasses, annual forbs and perennial forbs, further divided by the distinction between native and non-native species. Each of these guilds represents different ecological strategies for survival in grasslands. Presidio clarkia represents a small portion of the (native) annual forb data presented.

ANNUAL FORBS

Results from 2010 were not different than 2009 results for each of the four treatments. Notably, the results from the spring mow plots indicate that annual forbs have increased from the baseline conditions (Figure 7). Two years of successive mowing did not show a stepwise increase in results.

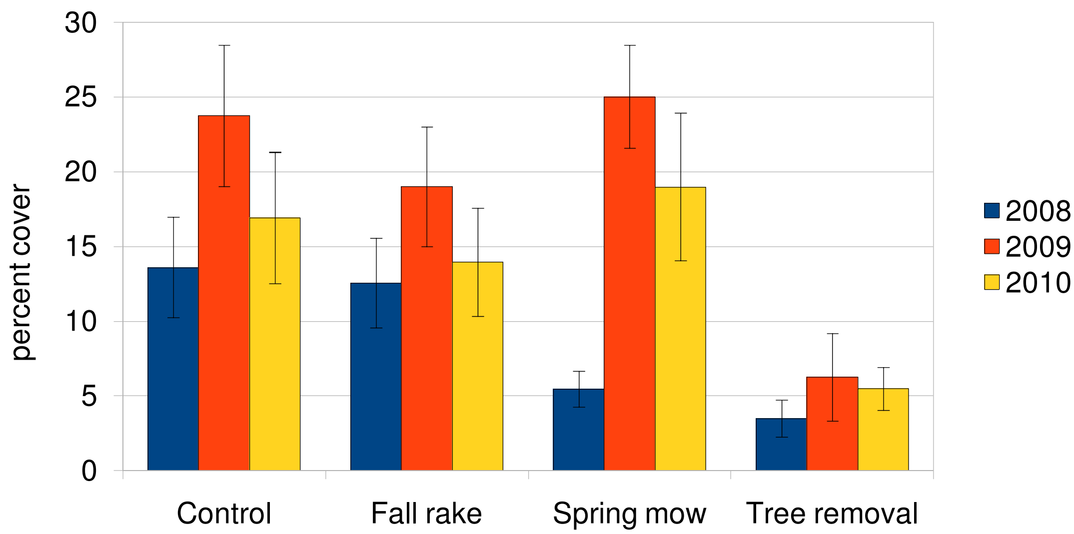


Figure 7: Percent Cover of Annual Forbs

NON-NATIVE ANNUAL GRASSES

Annual non-native grasses were not affected in three of the four treatments, but one year of mowing produced a sizable reduction in cover of non-native annual grass in the spring mow plots (Figure 8). Cover was reduced from 45.8 ± 2.7 to 30.1 ± 2.1, which equates to roughly a 33% decrease in one year of treatment. In 2010, a further reduction in non-native annual grass cover was observed. The average cover was reduced to 22.3 ± 4.2, a reduction of greater than 50% for the duration of the 2 years of treatment. This technique has produced the most noteworthy results for controlling non-native annual grasses.

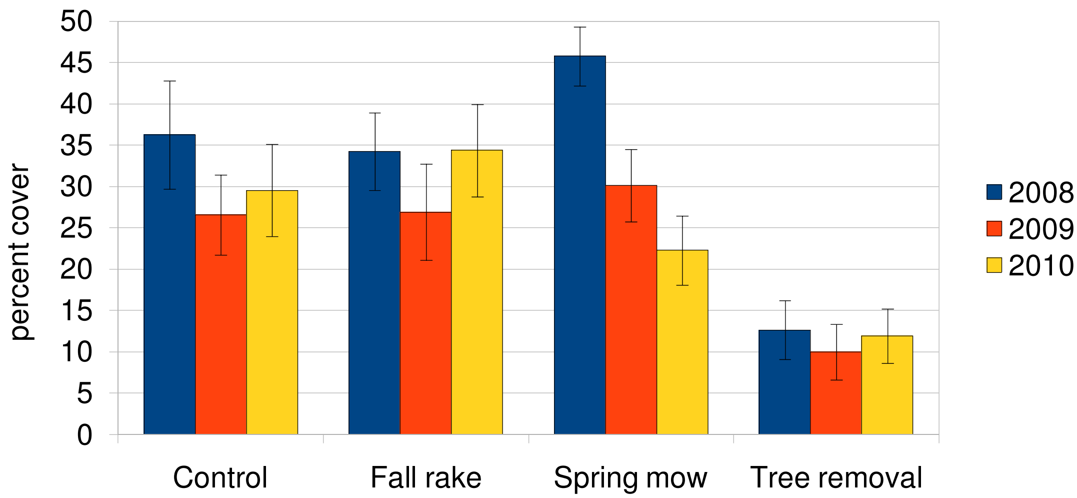


Figure 8: Percent Cover of Non-Native Annual Grass

NATIVE PERENNIAL GRASSES

No appreciable difference was observed in the cover of native perennial grasses, from 2008 to 2010 (Figure 9).

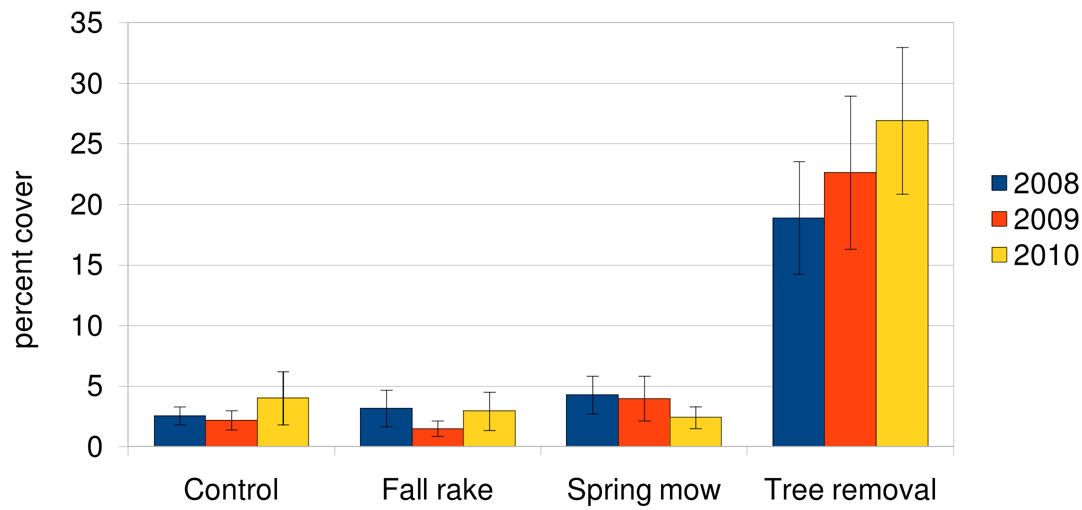


Figure 9: Percent Cover of Native Perennial Grass

NATIVE PERENNIAL FORBS

No appreciable effects on native perennial forb cover were recorded in three of the four treatments, but tree removal plots do show a small increase in perennial forb cover by Year 2 (Figure 10).

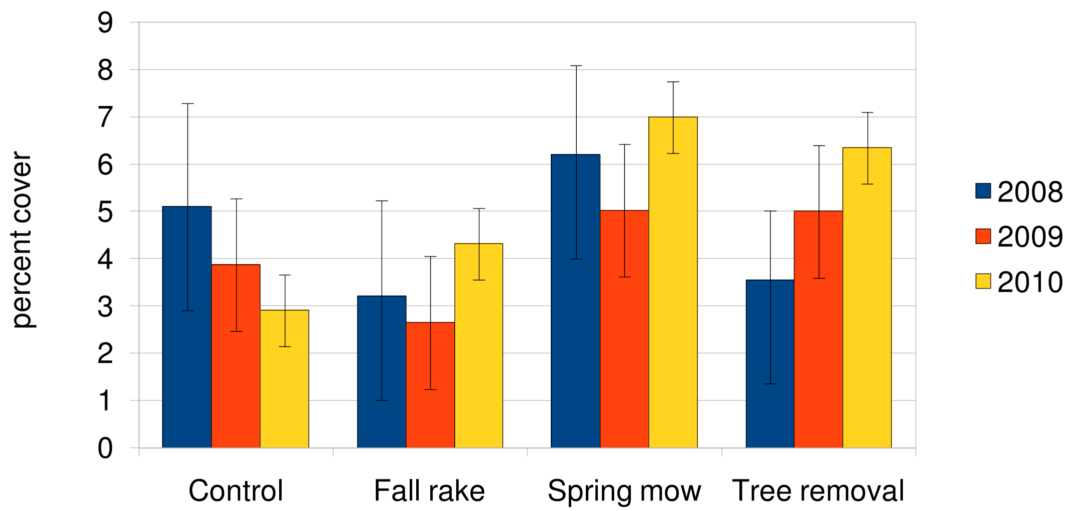


Figure 10: Percent Cover of Native Perennial Forbs

NATIVE AND NON-NATIVE PLANTS

Spring mowing was the only treatment to observably increase native cover and decrease non-native plant cover after one year of treatment (Figures 11 and 12). In 2010, the vegetation underneath the removed pines (tree removal) had become distinctly more native as compared to the 2008 data.

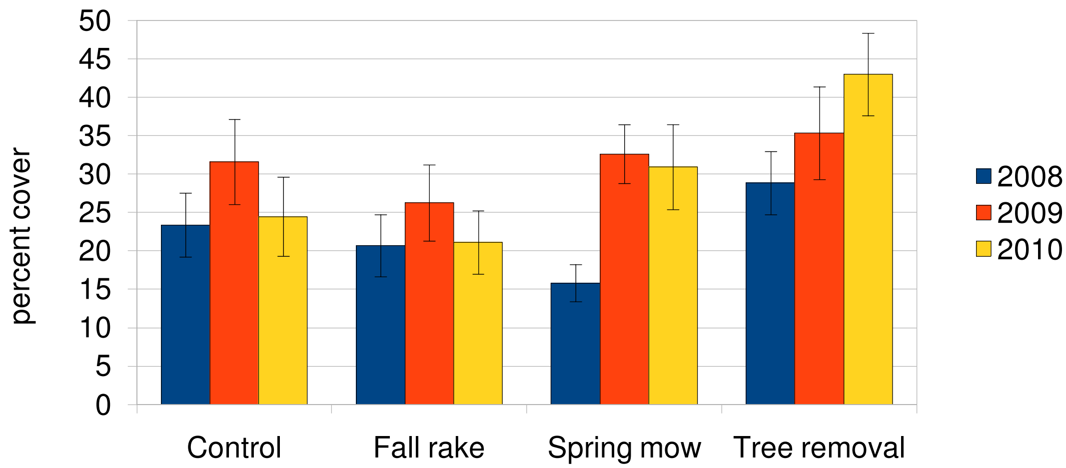


Figure 11: Percent Cover of Native Plants

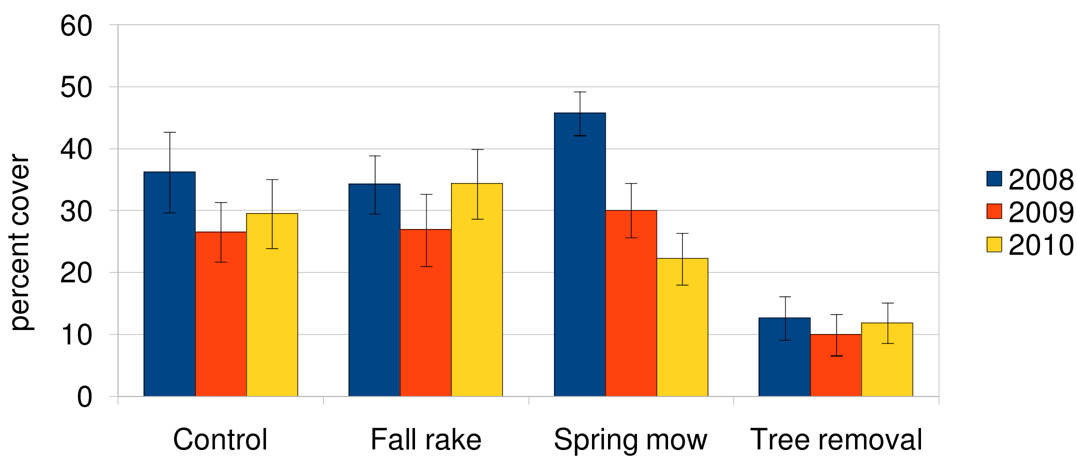


Figure 12: Percent Cover of Non-Native Plants

NATIVE LEGUMES

Increases in legume cover in year 1 in the control, fall rake, and spring mow treatments have not persisted (Figure 13).

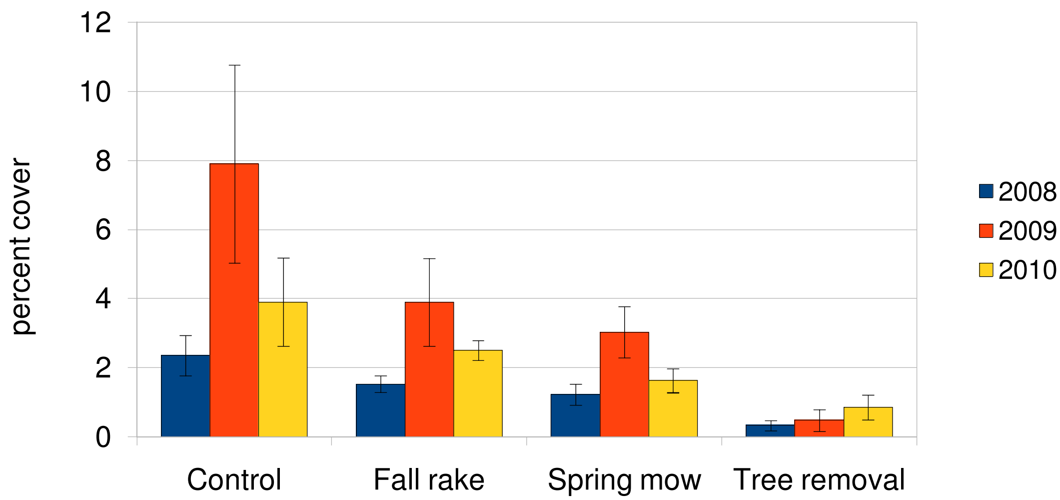


Figure 13: Percent Cover of Native Legumes

Enclosure Comparison

Our experimental design allows for vegetation comparison inside and outside the enclosure, to determine the effect of excluding foot traffic and dog use in portions of the serpentine prairie habitat.

Since the enclosure fence was built in December 2009, it is too soon for vegetation changes to occur inside the fence. Data comparing vegetation inside and outside of the fence will be presented in year 3 once the enclosure has been in place for one full vegetative season.

Discussion

Clarkia Population

Climate variability is an important factor that affects the population and distribution of Presidio clarkia. In years when spring precipitation was higher, clarkia population estimates for the macroplot increased. The magnitude of increase documented is similar to observations at the Presidio in San Francisco. The control plots confirmed the effects of weather on all vegetation by showing an increase in native annual forb cover and legumes.

Even with increased spring precipitation in 2010, fall rake plots showed a notable decline in clarkia for reasons unknown. Census counts decreased from 3254 in 2009 to 935 in 2010. It is possible that the raking treatment removed seeds from the plot to adjacent areas, and although no quantitative measurements were taken, no substantial increase in clarkia was observed adjacent to the 10x10 meter plots.

Clarkia increased in the spring mow plots from 0 to 24 individuals in year 1, but declined to 2 in year 2. While the numbers are too low to detect true trends, it is important to note that clarkia have colonized areas that receive a spring mow, a treatment originally considered to be too destructive for clarkia. Two subsequent years of mowing may have negative impacts on clarkia, or the small numbers may reflect a stochastic event (perhaps a gopher dug up the small clarkia cluster).

Clarkia counts in tree removal plots increased 54-fold over 2008 numbers. We consider this increase to be a response to tree removal. We expect that population numbers may increase in year 3 even more dramatically with continued tree removal.

Vegetation Composition

Treatments affected vegetation composition at each of the plots. Fall rake plots increased bare ground and decreased thatch, as anticipated. However, an associated increase in native cover and clarkia did not occur. Instead, clarkia unexpectedly declined in the fall rake plots. Before the experiment began, fall treatments were expected to be the most conservative to clarkia, and spring treatments were thought to be potentially harmful. Because seeds remain upright on senescent plants well into fall, however, fall treatments may affect seeds.

Spring treatments targeting grass growth may occur early enough that the late-season clarkia may be too short to be cut or may recover from impact.

The spring mow reduced non-native annual grasses by over 50% after only two years, while native annual plants increased nearly 4 fold from pre-treatment conditions. Native vegetation, native annual forbs, and bare ground increased in these plot treatments, indicating that desirable species or conditions were replacing the non-native annual grasses and thatch. Tree removal decreased thatch and slightly increased perennial grasses and native cover. Again these results are encouraging because only three of the eight plots were treated by the survey time.

With the new enclosure on the Prairie, we didn't expect an immediate difference between inside and outside plots. We observed more thatch and more vegetation inside the enclosure growing after the spring surveys, and believe two factors are responsible for this observation. We are nearly certain that the wetter climate increased total biomass throughout the study area, although we did not measure biomass specifically. Secondly, without the regular impact of people and dog traffic inside the enclosure, we believe that more thatch and vegetation was left standing.

Cover of perennial grasses are largely unaffected by any treatment. Since native perennial grasses in serpentinite tend to grow slowly, we anticipate that native grass cover will be a good indicator of general prairie grassland composition over a long time period, but short-term changes will be more difficult to observe.

Year 3 Proposals

The Serpentine Prairie restoration project is well underway, with several interesting results. Treatments that yielded positive results should be scaled up, and data from newly implemented treatments (tree removal and fencing) will continue to be collected.

The highest priority is expanding the spring mowing treatment to a larger area where clarkia is not present, or is present in low numbers. The dramatic results of lowered annual grass and increased annual forb cover should be scaled up at the Prairie. Two subsequent years of treatment may be required to achieve the best results. Specific areas to be mowed will be delineated with park staff in early spring.

In year 3, we will no longer treat the spring mow plots but will record how long it takes vegetation to revert to baseline conditions without management. This will inform managers how regularly mowing should occur. A third year of consecutive spring mowing is not recommended because it is believed that native species, including clarkia, will benefit from a “rest” year when seed set can occur.

Fall rake treatments have not produced desirable results. Based on the above-documented results with clarkia count data, fall rake plots will be read one last time in spring 2011, but treatments will likely not be repeated based on documented clarkia take.

Year three will provide a clearer picture on the continued effect of spring mowing, tree removal, and fencing.

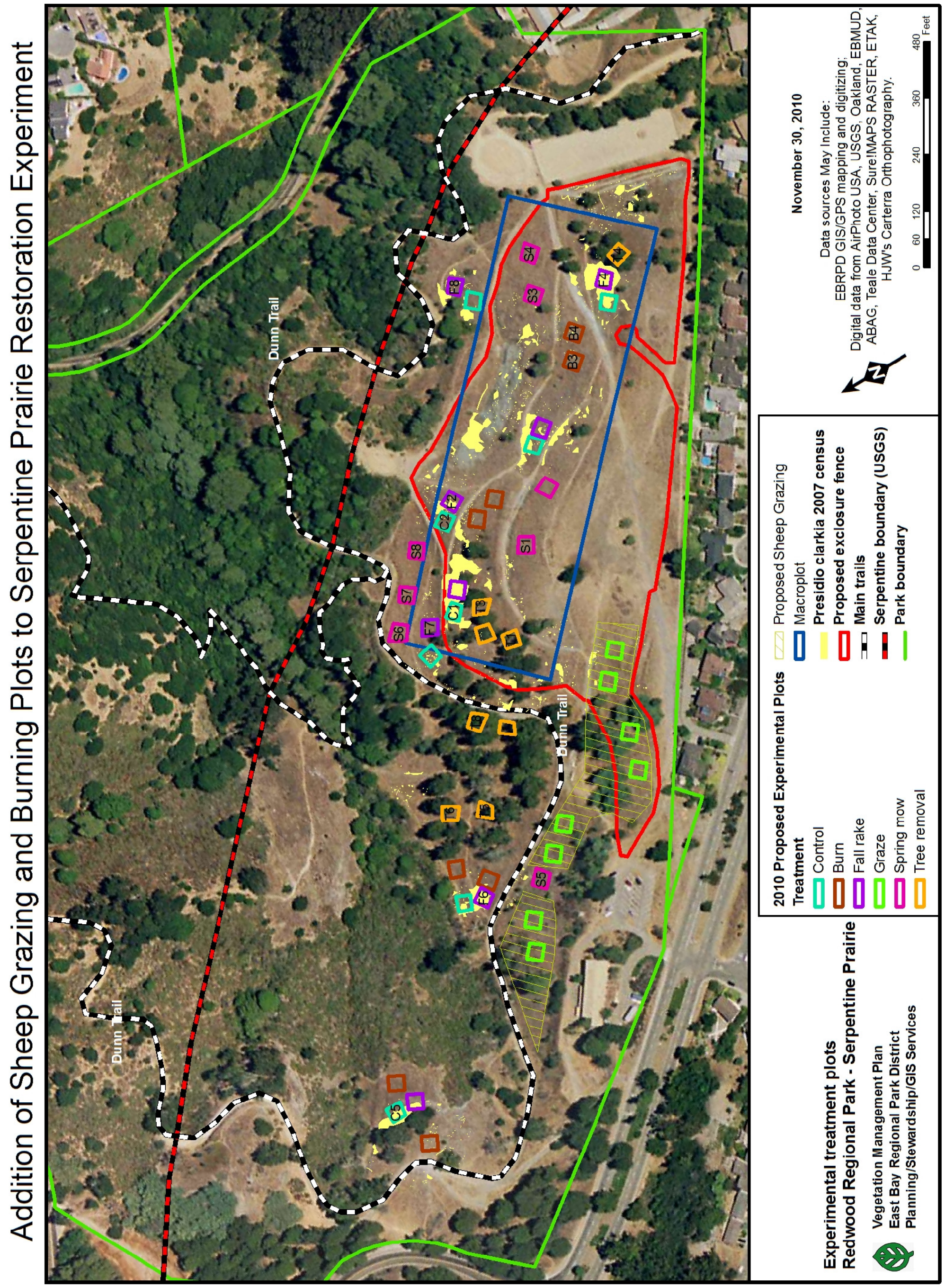
Additional treatments should also be instituted, to see how they compare with existing ones. We encourage the Park District to consider initiating a small, closely managed sheep grazing experiment. Sheep are recommended because they are labeled intermediate feeders, which have no particular preference for grasses, forbs, or shrubs (Sotoyome Resource Conservation District).

Spring grazing is recommended to more closely mimic our most successful treatment, spring mowing, rather than our least successful treatment, fall raking. While sheep grazing is likely to reduce thatch and increase bare ground, reducing annual grass while it is growing appears to be a key factor in improving habitat conditions for clarkia and other desirable native species. Sheep can be managed effectively for grazing specific areas utilizing a portable electric fence and water troughs. We recommend an additional set of experimental plots to compare the grazing treatment with the other treatments already in place (Map 5). Specific placement of new monitoring plots will be coordinated with the EBRPD Wildland Vegetation Project Manager.

Prescribed fire is another tool that should be tried experimentally at the Prairie. Fire can reduce annual grass, reduce thatch, and increase bare ground, conditions that favor clarkia recruitment and germination. We continue to encourage an experimental burn treatment in the Prairie (Map 5).

In year 3 we will monitor germination and maturation of translocated clarkia seeds. The three areas where seeds were sown will be surveyed in the spring and summer of 2011 (Map 4). If clarkia successfully establishes in these new areas, further seed collection and sowing will be recommended.

Map 5: Proposed addition of sheep grazing and burning plots



References

Creekside Center for Earth Observation. 2008. Serpentine Prairie Restoration Project, Redwood Regional Park. Submitted to East Bay Park District.

Creekside Center for Earth Observation. 2009. Serpentine Prairie Restoration Project, Redwood Regional Park Year 1. Submitted to East Bay Park District.

East Bay Regional Park District (EBRPD). 2008. Serpentine Prairie Restoration Plan. Oakland, California.

Sotoyome Resource Conservation District. 2010. The Grazing Handbook. Santa Rosa, California.

Westmap. 2010. Climate Analysis and Mapping Tool. Accessed on November 22, 2010. http://www.cefa.dri.edu/Westmap/Westmap_home.php